

# NASA TECH BRIEF



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## Metallic Diffusion Measured by a Modified Knudsen Technique

Diffusion in pure metals and alloys is of both fundamental importance and practical interest; many solid-state reactions are controlled by diffusion. Many industrial processes rely on the diffusion of matter through a thin foil or layer where both inward and outward diffusion occur; in this case the bulk-diffusion coefficient may not suffice for calculation of the useful lifetime of a metal or alloy.

A new method has been found for determination of the diffusion coefficient of a metal in a high-temperature system. From measurement of the weight loss from a Knudsen cell, the vapor pressure of the escaping species can be calculated. If the only way this species can enter the Knudsen cell is by diffusion through a foil, the steady-state weight loss (the flux leaving the cell) is also the diffusion flux.

The composition of the surface of the foil in the cell is given by the vapor pressure in the cell and the thermodynamics of the system. The composition of the other foil surface can be controlled by the external vapor pressure of the diffusing material. With these data and the thickness of the foil, the diffusion coefficient can be calculated from Fick's First Law.

This technique has been used for study of the diffusion of zinc through silver foil at five temperatures between 500° and 800°C, and at 1,000°C. When at 1,000°C the foil's thickness is varied, for the same drop in concentration the flux is inversely proportional to the thickness; thus diffusion, and not the transport of zinc vapor into and out of the foil, controls the flux.

After diffusion of zinc at 1,000°C, the silver foils are virtually unaffected. Foils used at lower temperatures, however, show considerable porosity near the surface from which the zinc leaves the foil; this effect increases markedly with decrease in temperature.

Thus the transport of one metal through another, having a lower diffusion coefficient, produces considerable porosity that results in decrease in the diffusion path, with corresponding increase in the mass transport. This fact is directly important in many industrial processes. In galvanizing, for example, zinc must diffuse through several intermetallic compounds in order to react with the iron; because of the greater diffusion coefficient of the zinc, one should expect a tendency for porosity to occur in these layers, with consequent reduction in adhesion, mechanical strength, and corrosion resistance of the coating.

### Note:

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